CLAIMS:

1. An organic light-emitting diode (OLED) device that produces white light, including:

a) an anode;

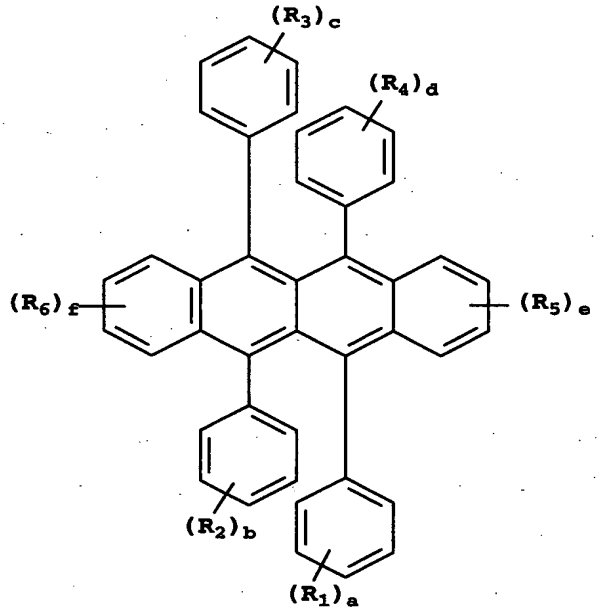
b) a hole-transporting layer disposed over the anode;

c) a blue light-emitting layer disposed over the hole-transporting layer;

d) an electron-transporting layer disposed over the blue light-emitting layer;

e) a cathode disposed over the electron-transporting layer; wherein

f) wherein the hole-transporting layer comprises an entire layer or a partial portion of a layer in contact with the blue light-emitting layer and contains a light-emitting naphthacene compound having formula (I)



Formula (I)

wherein

R_1, R_2, R_3, R_4, R_5 and R_6 represent substituents on each ring where each substituent is individually selected from alkyl or substituted alkyl groups of

from 1 to 24 carbon atoms; aryl or substituted aryl groups of from 6 to 20 carbon atoms; carbon atoms from 4 to 24 necessary to complete a fused aromatic ring; heterocyclic or substituted heterocyclic groups of from 5 to 24 carbon atoms, which may be bonded via a single bond, or may complete a fused heteroaromatic ring system; alkoxy or aryloxy groups, alkoxylamino, alkylamino, and arylamino groups of from 1 to 24 carbon atoms; and fluorine, chlorine, bromine or cyano substituents;

a, b, c and d are individually selected from 0 through 5;

e and f are individually selected from 0 through 4;

provided that at least one of R_1 through R_4 is not a fused ring group and at least one of R_1 through R_6 is a substituent; and

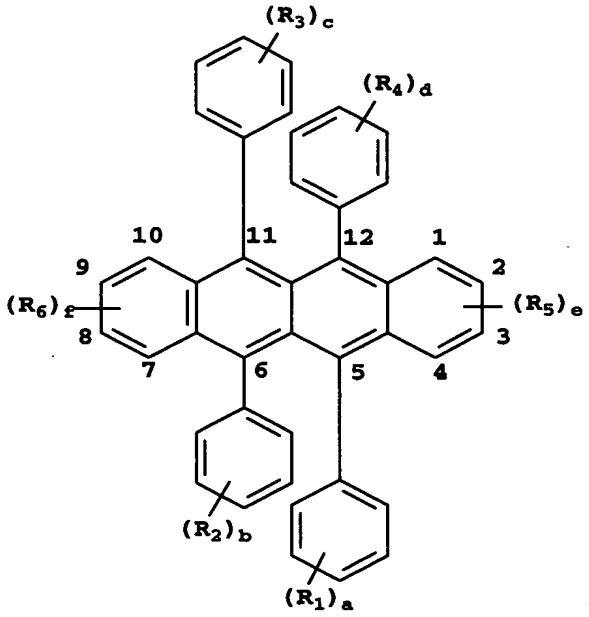
provided further that neither both R_1 and R_4 nor both R_2 and R_3 are heterocyclic.

2. The device of claim 1 wherein:

a) at least one of R_5 and R_6 are selected from aromatic or heterocyclic groups; and

b) at least one of R_1, R_2, R_3, and R_4 contain at least one substituent identical to the aromatic or heterocyclic groups in paragraph a).

3. The device of claim 1 wherein the naphthacene is represented by formula (II):



Formula (II)

wherein:

a) there are identical aromatic or heterocyclic groups at the 2- and 8-positions;

b) the phenyl rings in the 5- and 11-positions contain para-substituents identical to the aromatic or heterocyclic groups in paragraph a); and

c) the phenyl rings in the 6- and 12-positions are substituted or not.

4. The device of claim 1 wherein:

a) at least one of R_5 and R_6 are selected from oxy, aza and thio groups; and

b) at least one of R_1, R_2, R_3, and R_4 contain one substituent identical to the oxy, aza and thio groups in paragraph a).

5. The device of claim 3 wherein:

a) R_5 and R_6 include identical oxy, aza or thio groups at the 2- and 8-positions;

b) the phenyl rings in the 5- and 11-positions contain para-substituents identical to the oxy, aza or thio groups in paragraph a);

c) the phenyl rings in the 6- and 12-positions are substituted or not; and

provided that when a single substituent is present on both phenyl rings in paragraph c), said substituent is not a methoxy group located at the para-position.

6. The device of claim 1 wherein:

a) R_5 and R_6 each contain at least one identical alkyl or non-aromatic carbocyclic group; and

b) R_1 and R_3 each contain at least one substituent identical to the alkyl or non-aromatic carbocyclic groups in paragraph a).

7. The device of claim 3 wherein:

a) R_5 and R_6 each contain at least one identical branched alkyl or non-aromatic carbocyclic group at the 2- and 8-positions;

b) the phenyl rings in the 5- and 11-positions contain para-substituents identical to the branched alkyl or non-aromatic carbocyclic groups in paragraph a); and

c) the phenyl rings in the 6- and 12-positions are substituted or not.

8. The device of claim 1 wherein the fused aromatic ring is selected from phenyl, naphthyl, anthracenyl, phenanthryl, pyrenyl, or perylenyl groups.

9. The device of claim 1 wherein the heterocyclic ring or fused heterocyclic ring system is selected from thiazolyl, furyl, thienyl, pyridyl and quinolinyl groups, which may be bonded via a single bond, or may complete a fused heteroaromatic ring system.

10. An organic light-emitting diode (OLED) device that produces white light, including:

a) an anode;

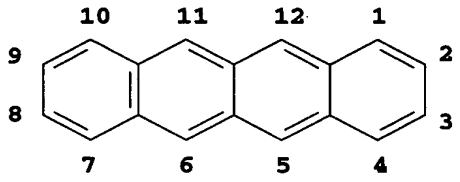
b) a hole-transporting layer disposed over the anode;

c) a blue light-emitting layer disposed over the hole-transporting layer;

d) an electron-transporting layer disposed over the blue light-emitting layer;

e) a cathode disposed over the electron-transporting layer; and

f) wherein the hole-transporting layer comprises an entire layer or a partial portion of a layer in contact with the blue light-emitting layer and contains a light-emitting naphthacene compound having formula (III)



Formula (III)

wherein:

i) said naphthacene contains at least one fluorine or fluorine containing group; and

ii) when exactly two fluorine containing groups are present said groups are not located each at the 5- and 12-positions nor each at the 6- and 11-positions.

11. The device of claim 10 wherein:

either

a) the sublimation temperature of said naphthacene derivative is lower by at least 5°C than the derivative without fluorine or fluorine containing groups;

or

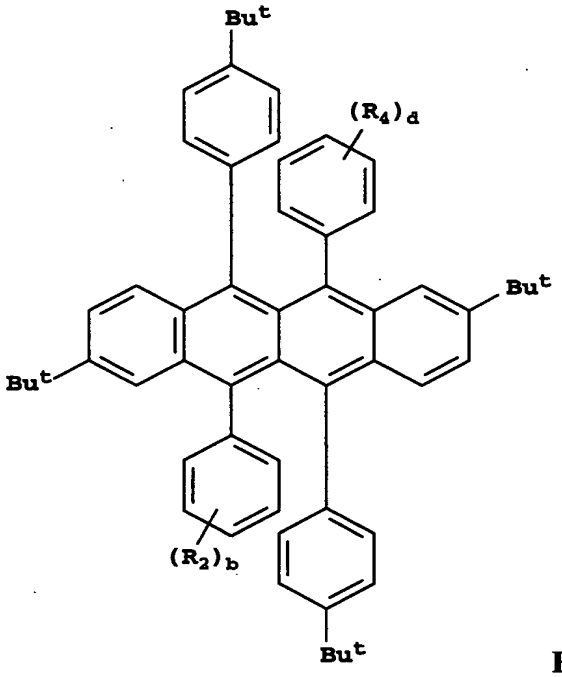
b) the naphthacene derivative sublimes and the derivative without the fluorine or fluorine containing groups melts.

12. The device of claim 3 wherein:

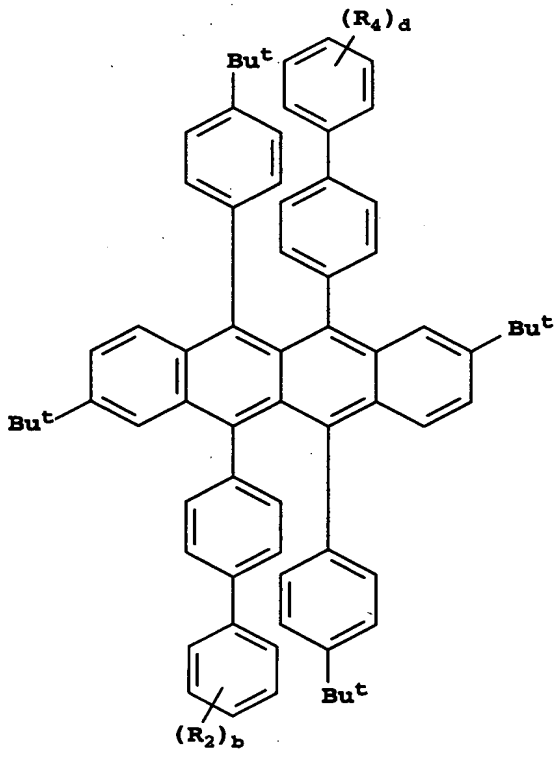
a) said naphthacene contains at least one fluorine or fluorine containing group on the phenyl groups located at positions 5, 6, 11, and 12 or at positions 1 through 4 or at positions 7 through 10; and

b) when exactly two fluorines are present said groups are not located each on the 5- and 12-positioned phenyls nor each on the 6- and 11-positioned phenyls.

13. The device of claim 1 wherein the naphthacene is represented by formulae (IV) or (V).



Formula (IV)



Formula (V)

14. The device of claim 1 wherein the naphthacene is selected from the group consisting of::

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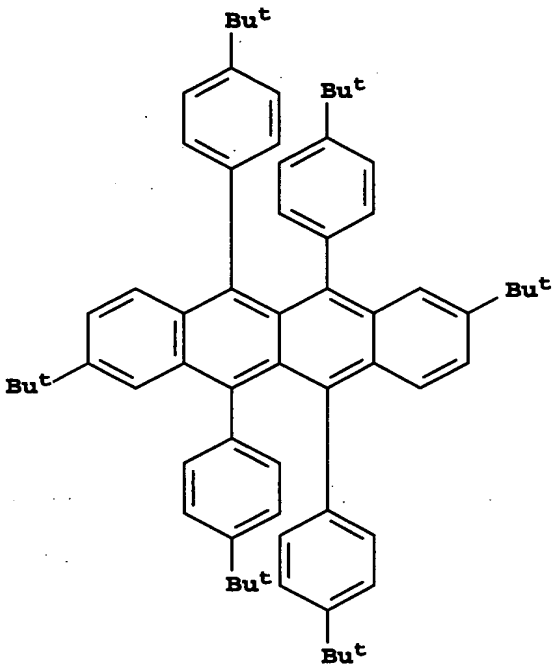

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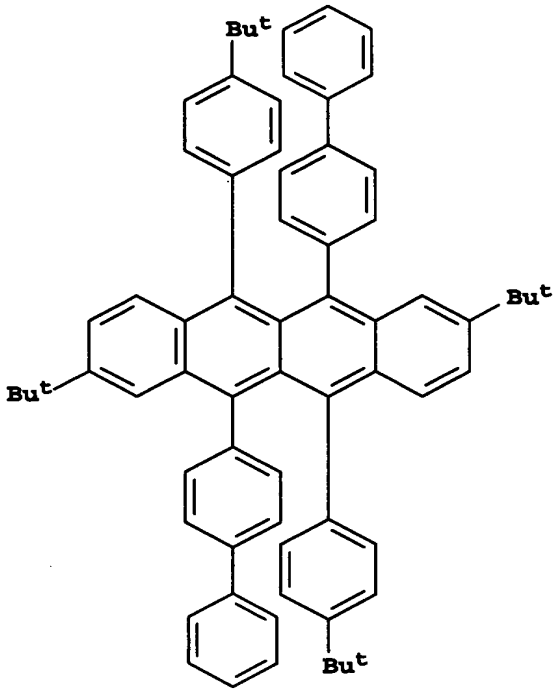

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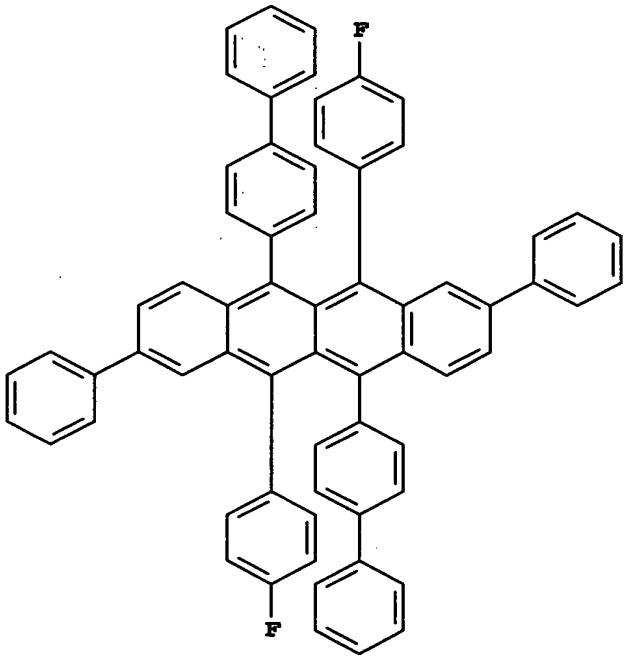

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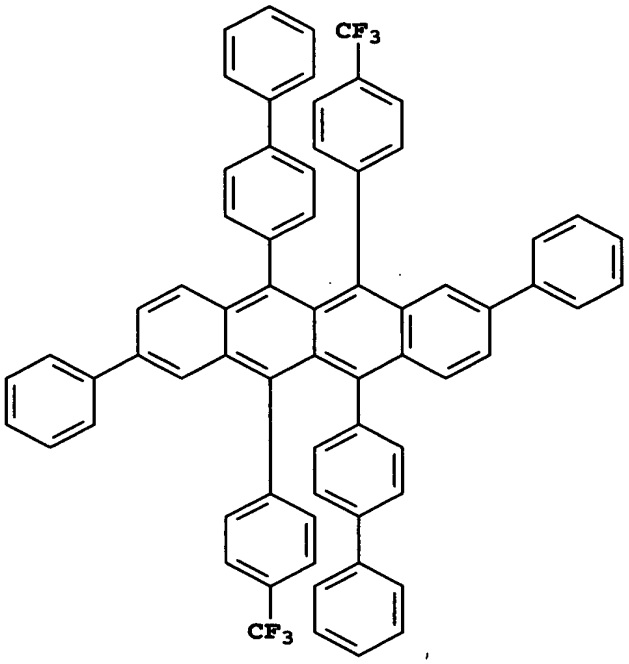

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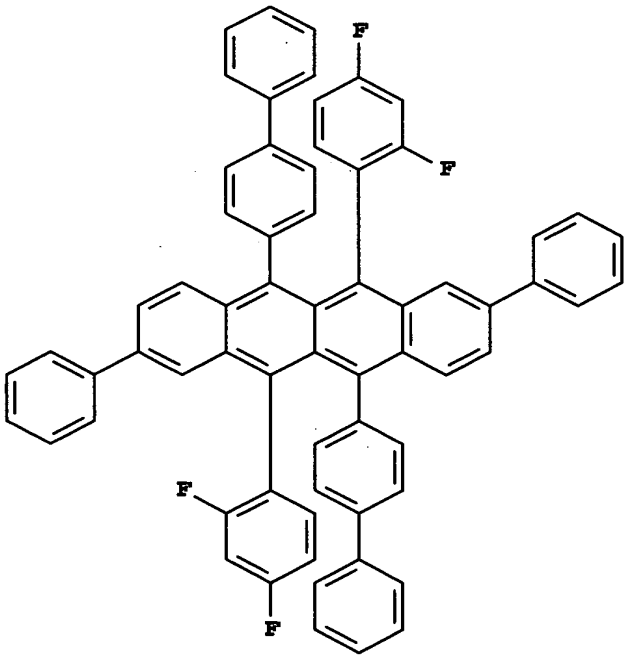

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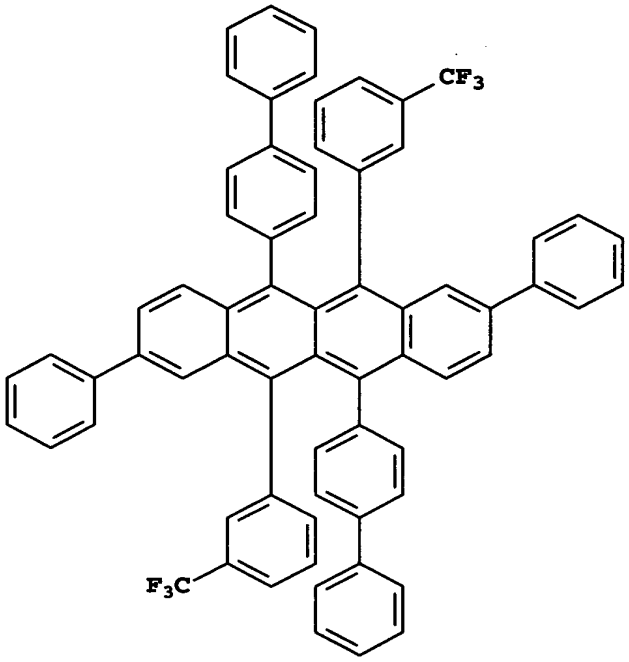

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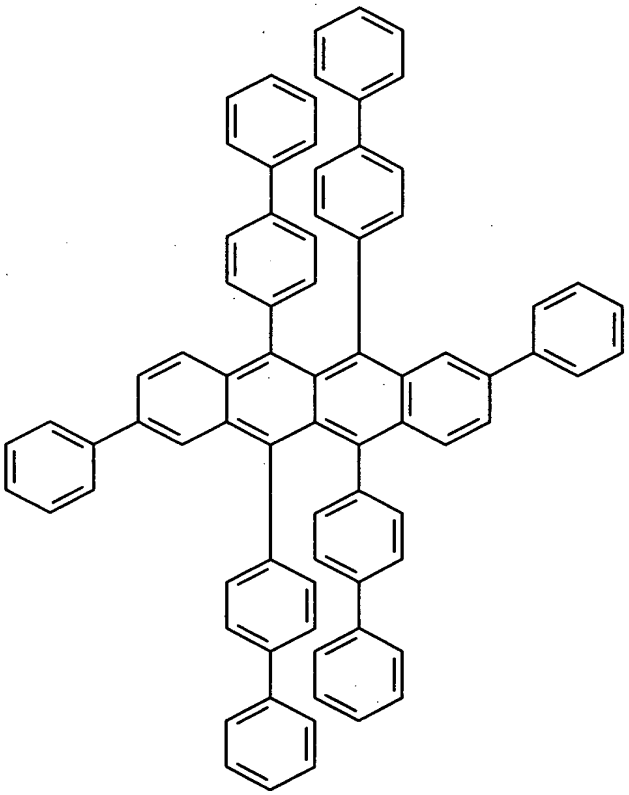

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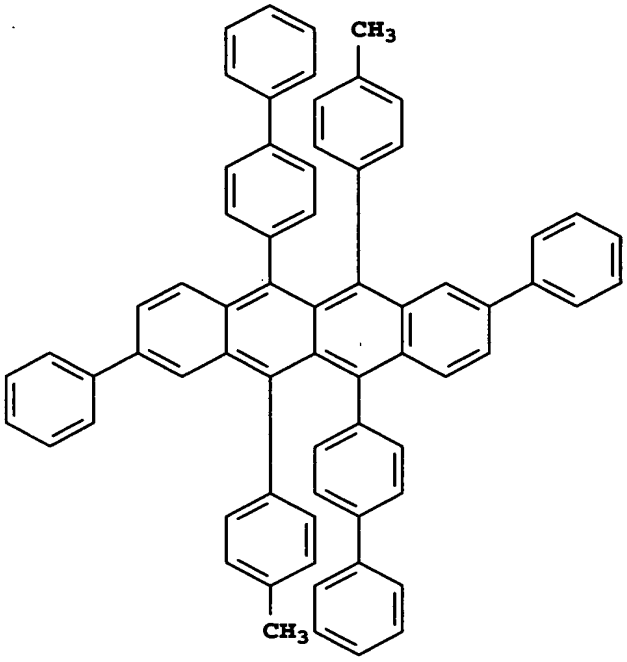

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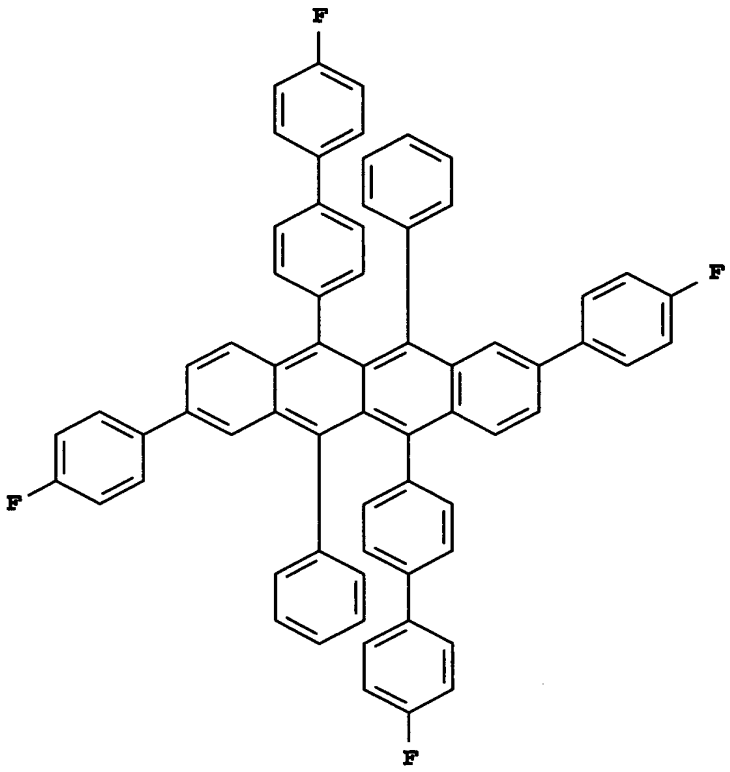

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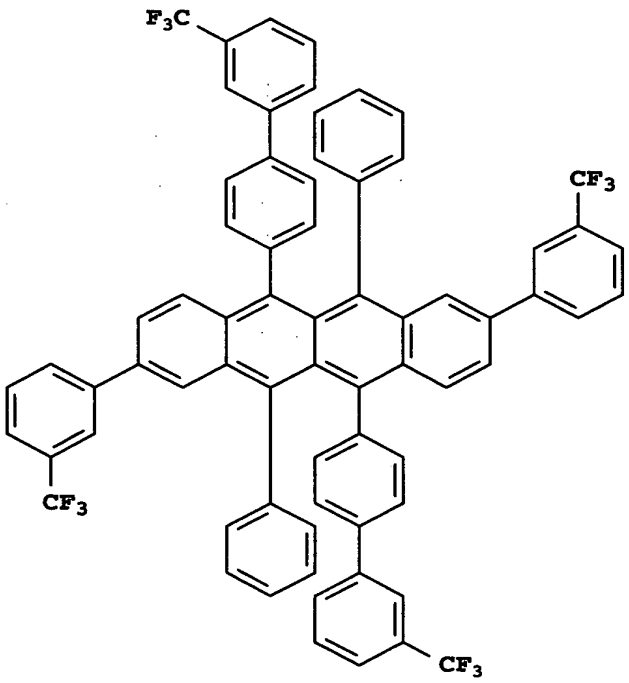

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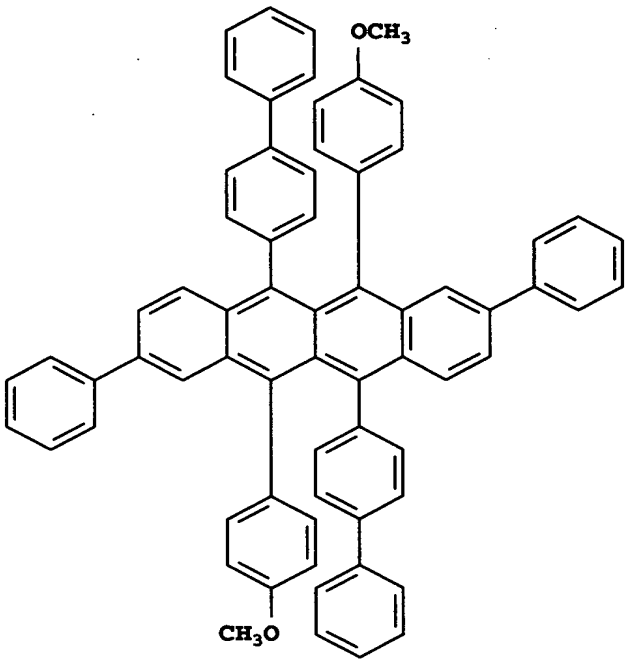

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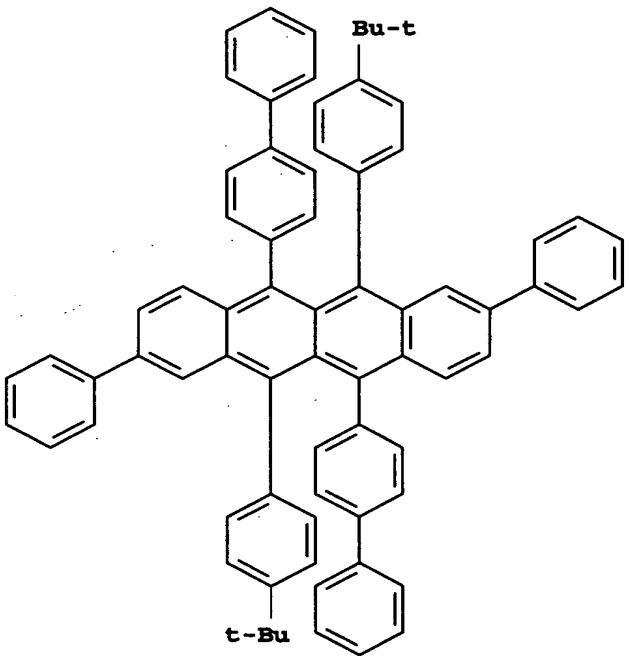

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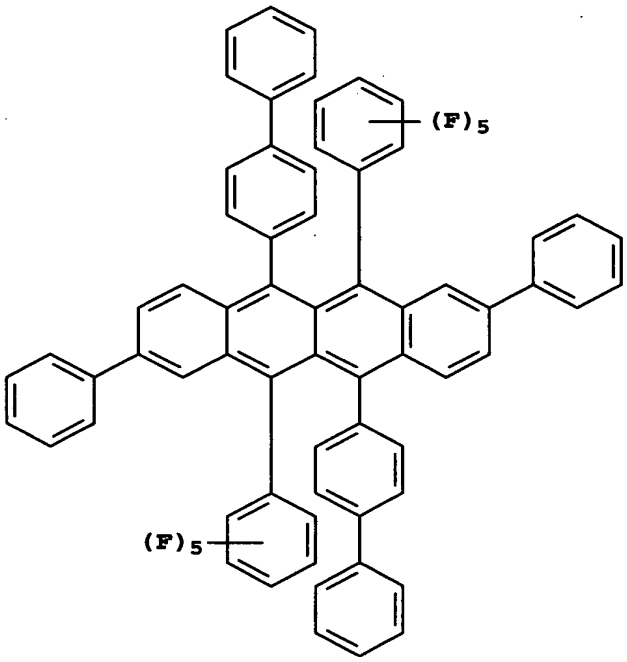

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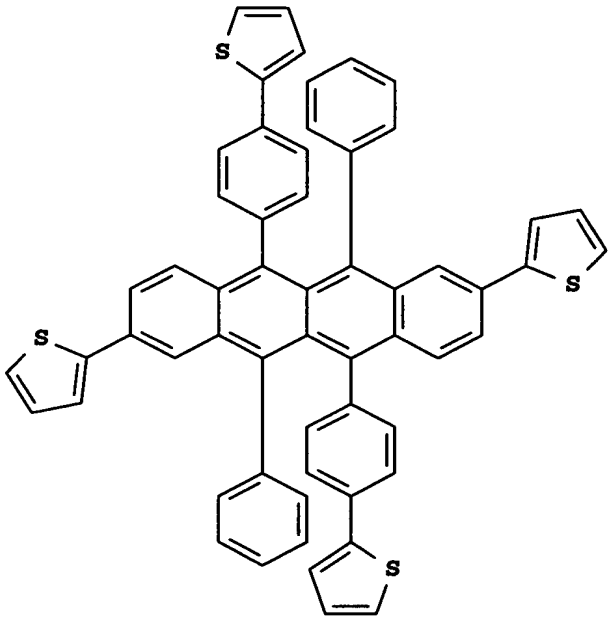

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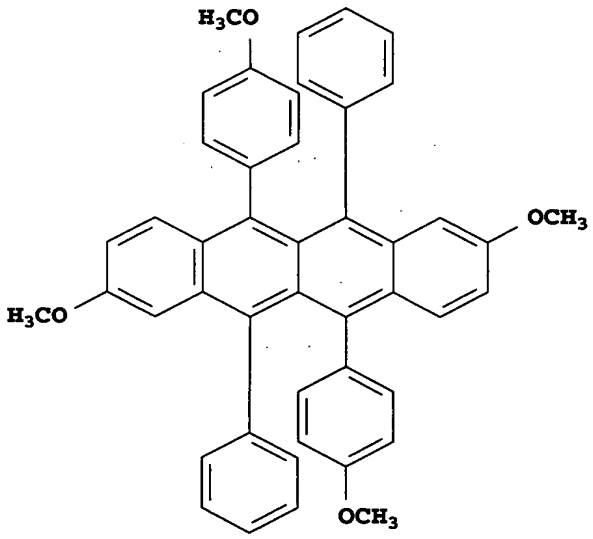

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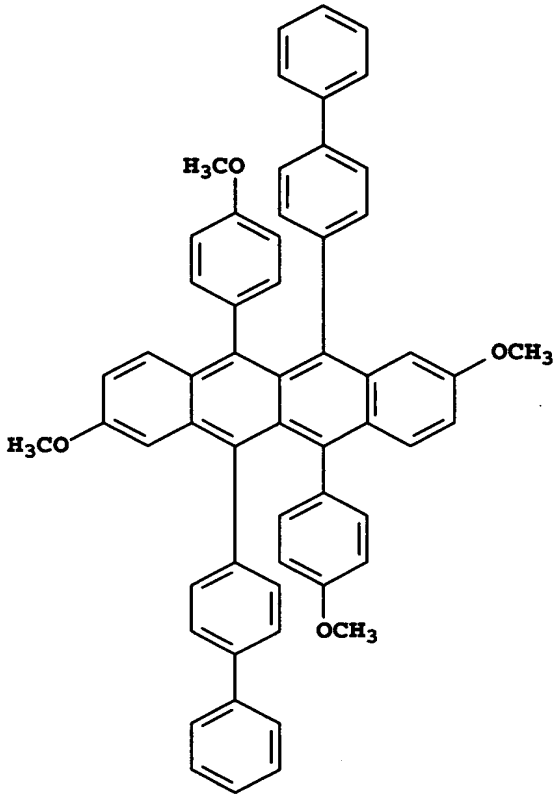

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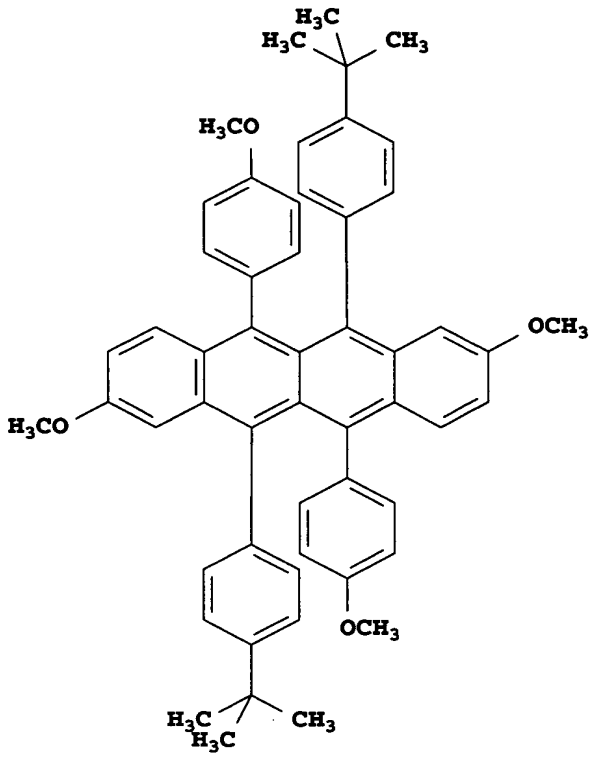

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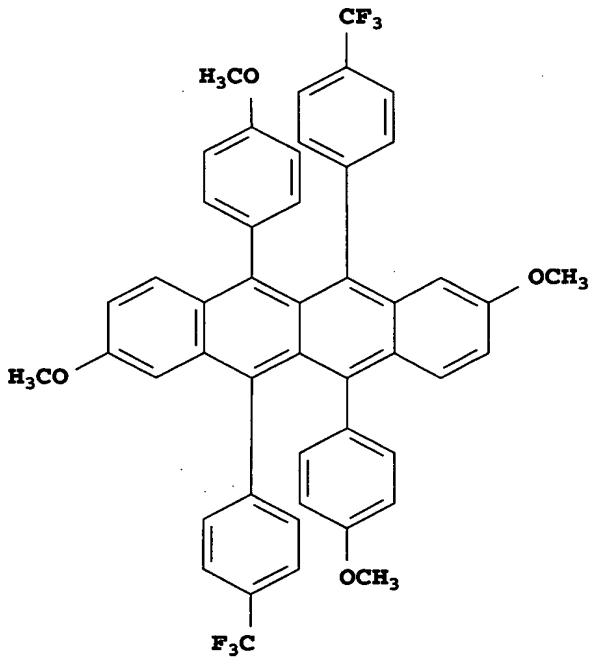

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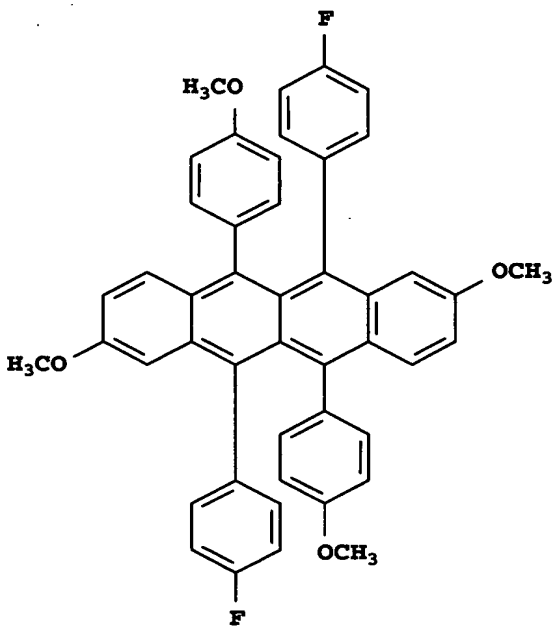

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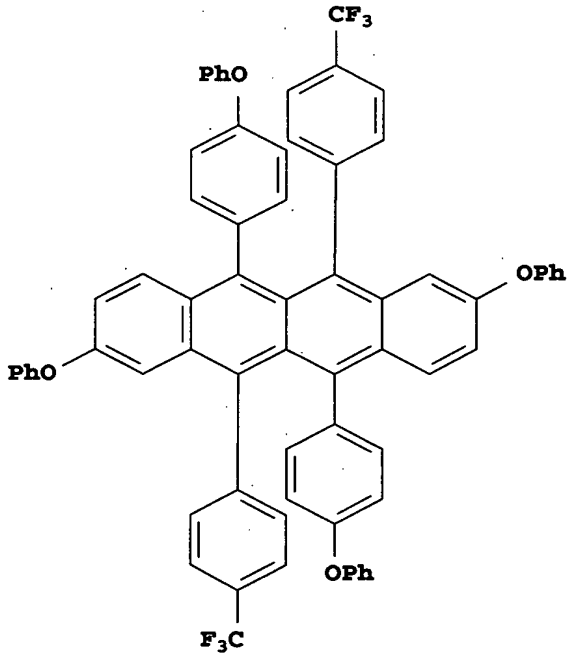

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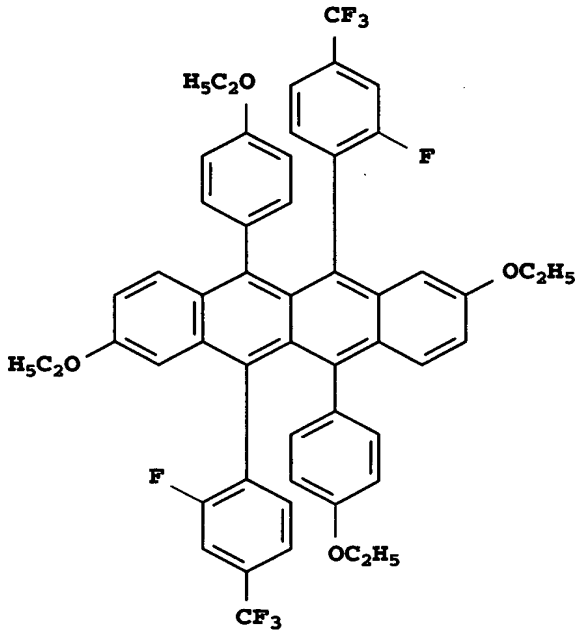

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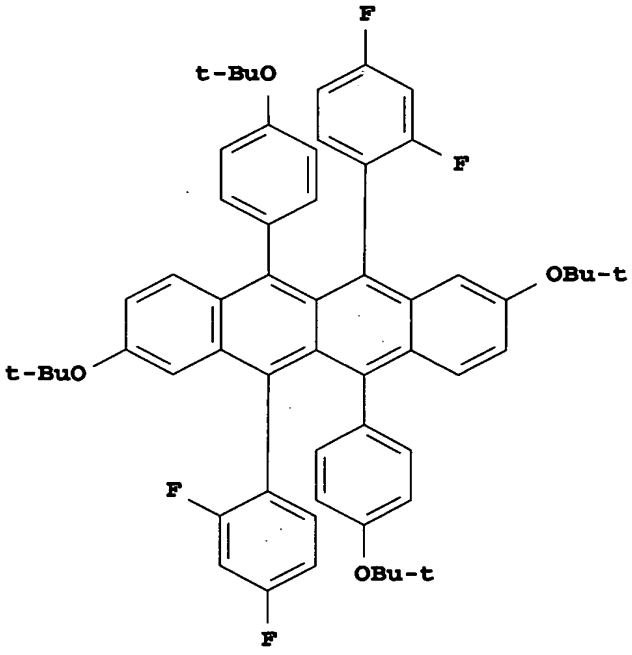

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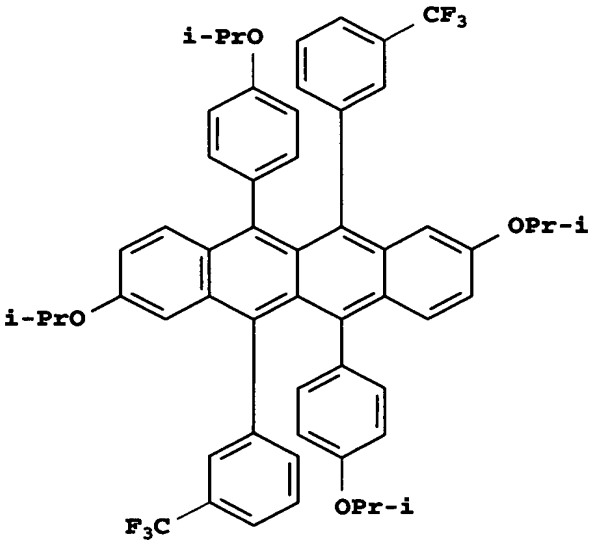

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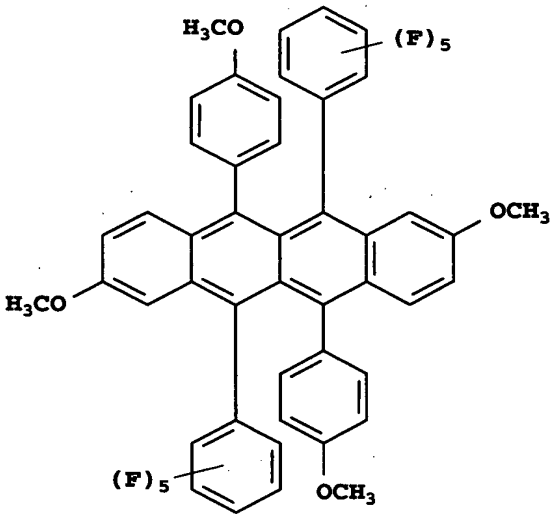

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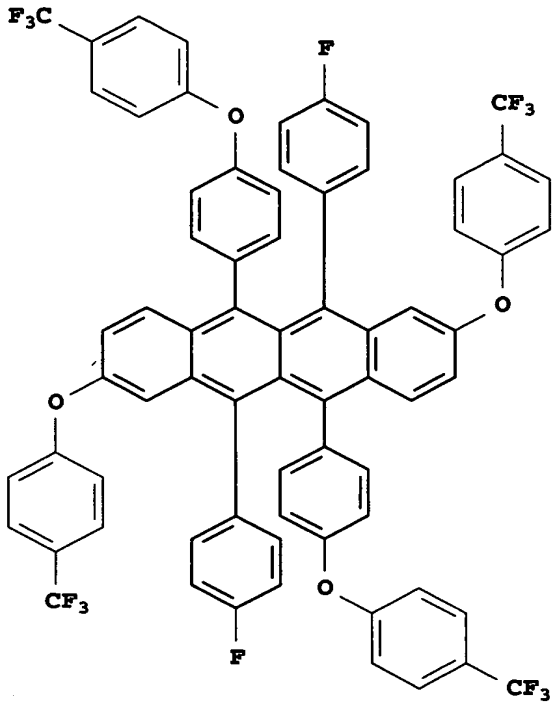

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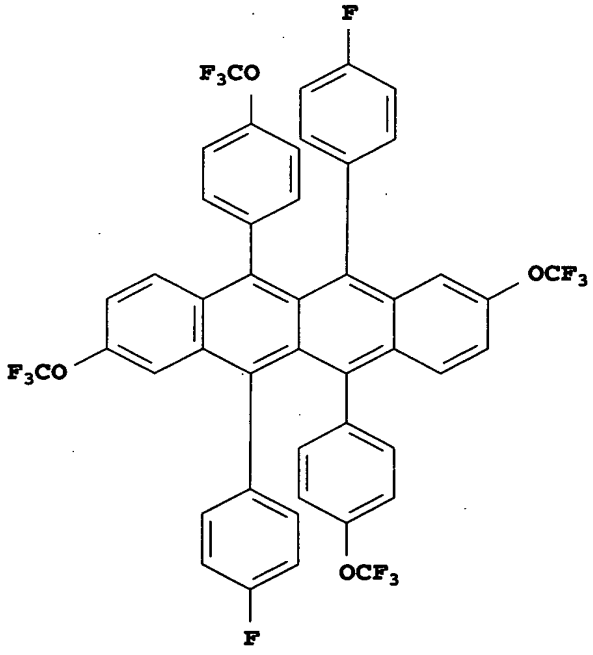

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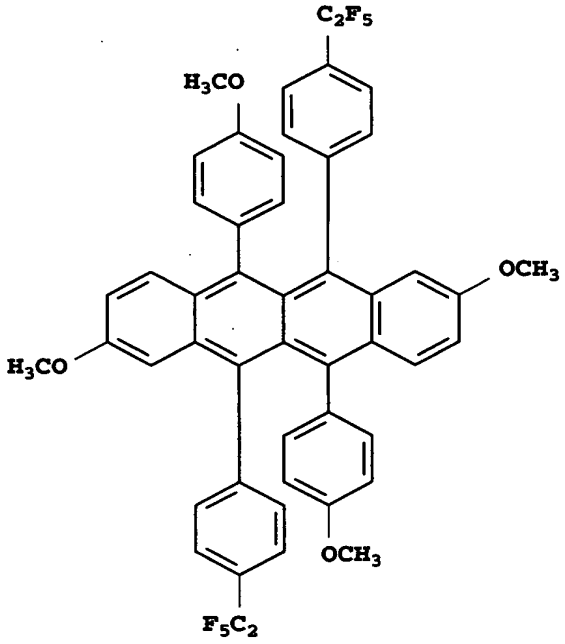
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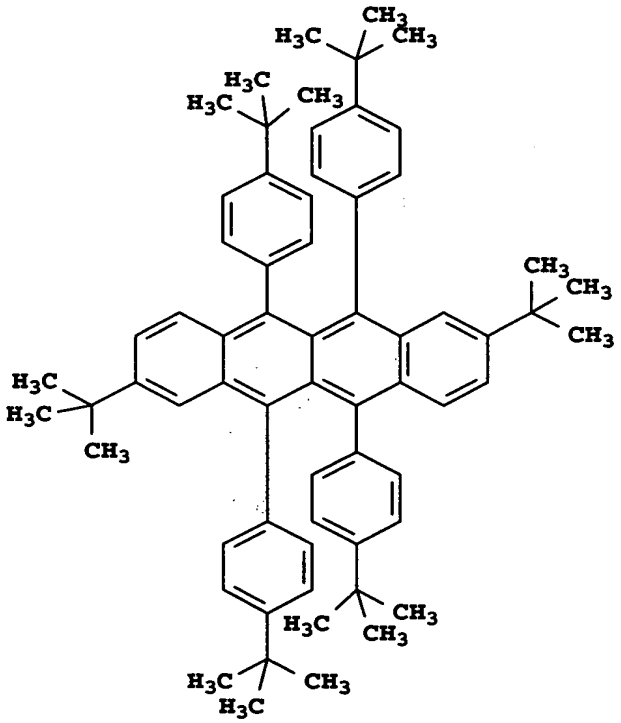
OCH3
H3CO
OCH3
F5C2

Inv-28


CH3
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CH3
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H3C
CH3
CH3
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CH3
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CH3
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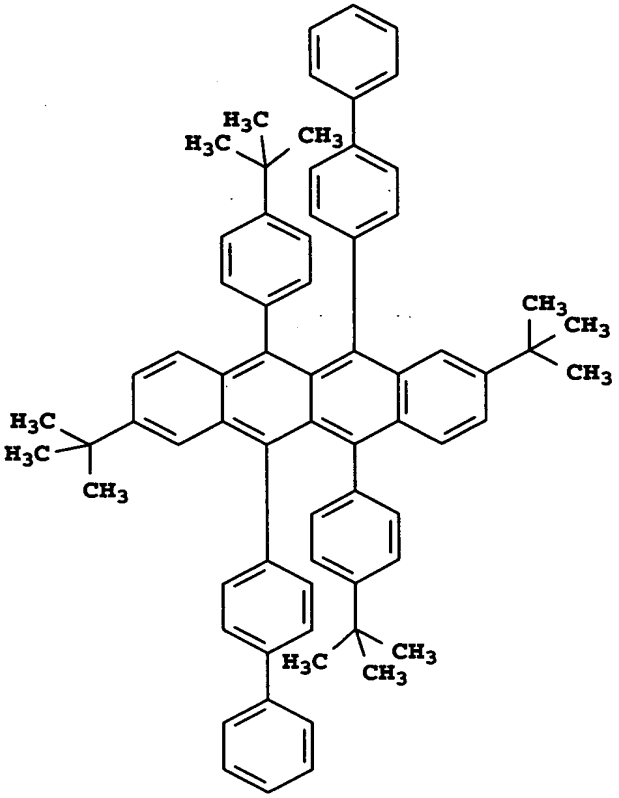
CH3
H3C

Inv-29



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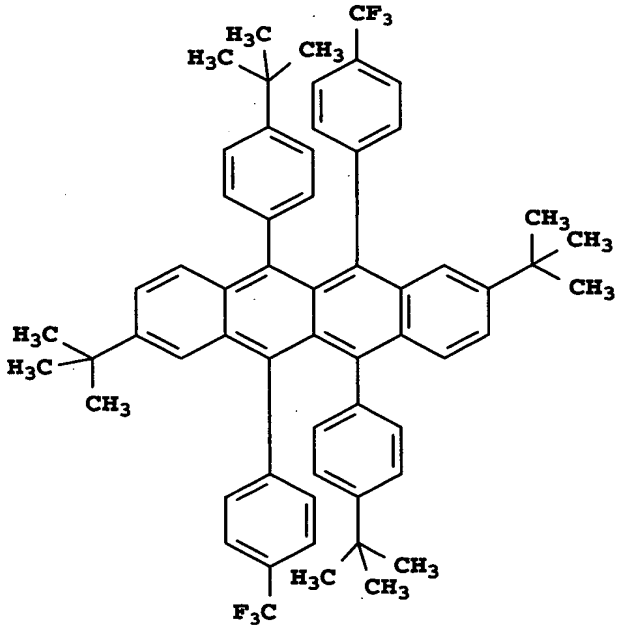

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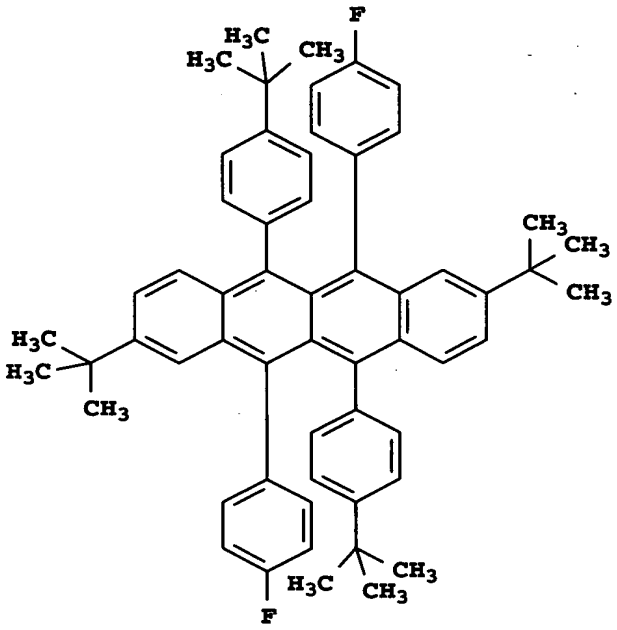

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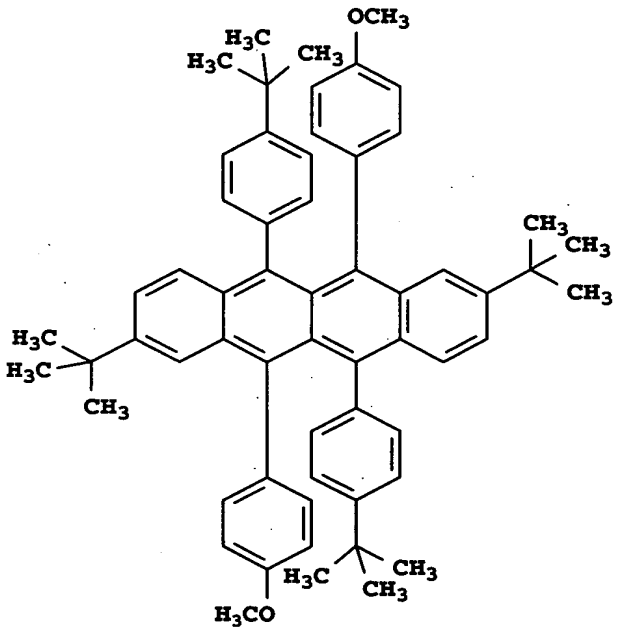

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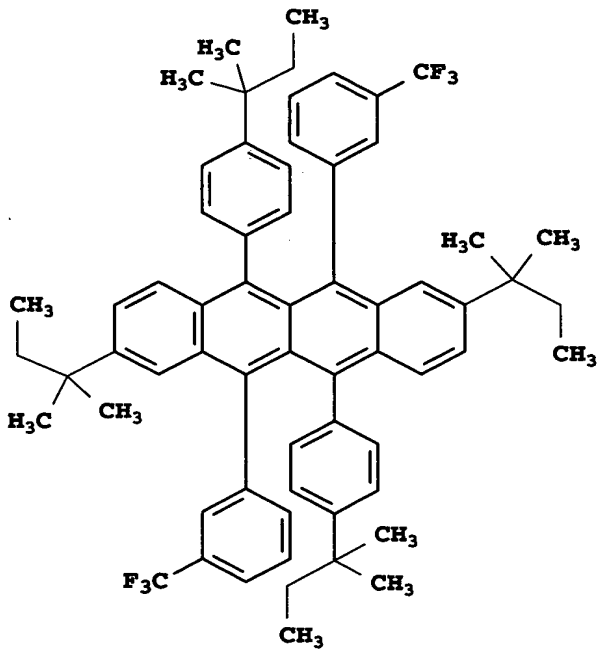

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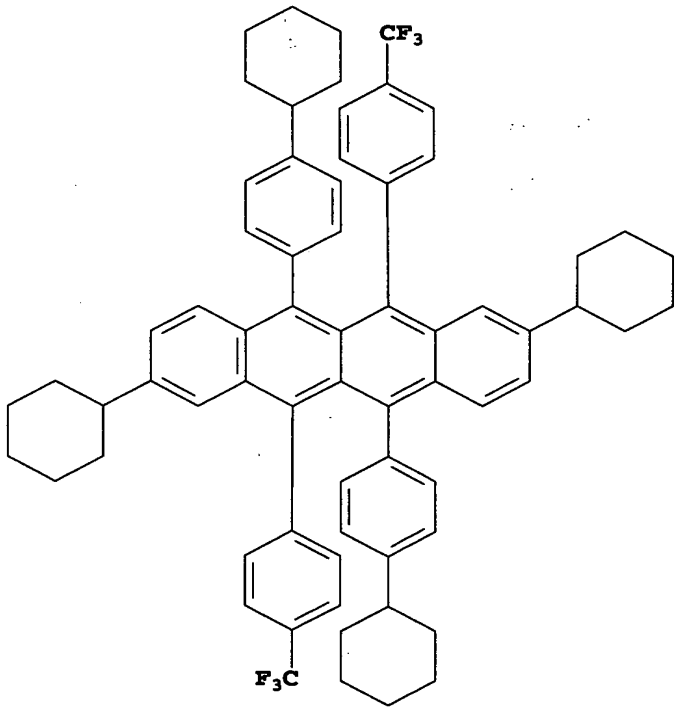

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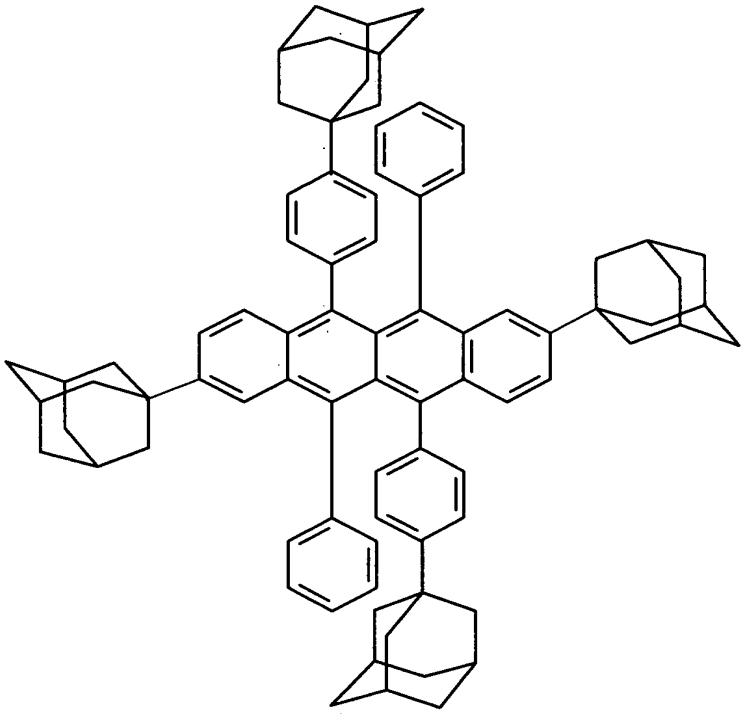

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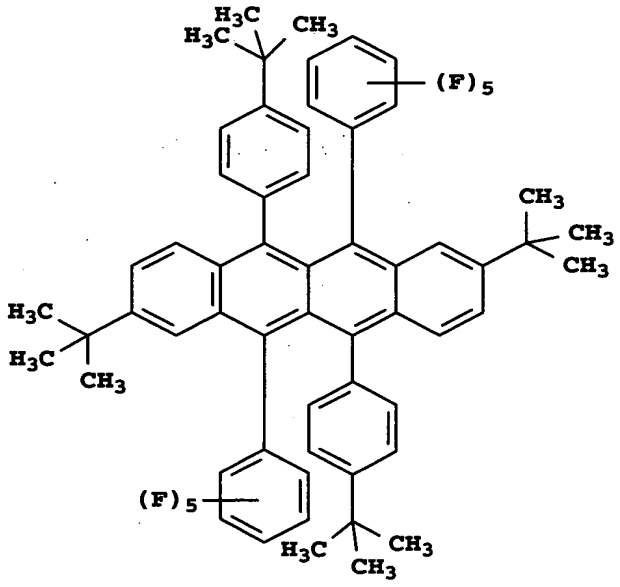

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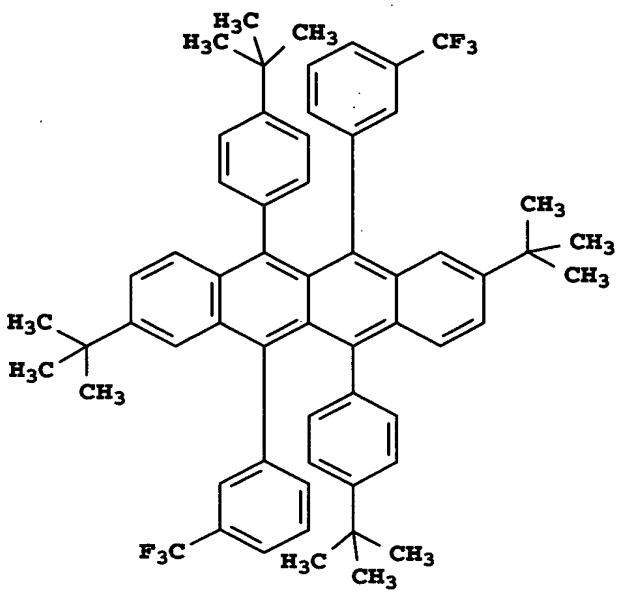

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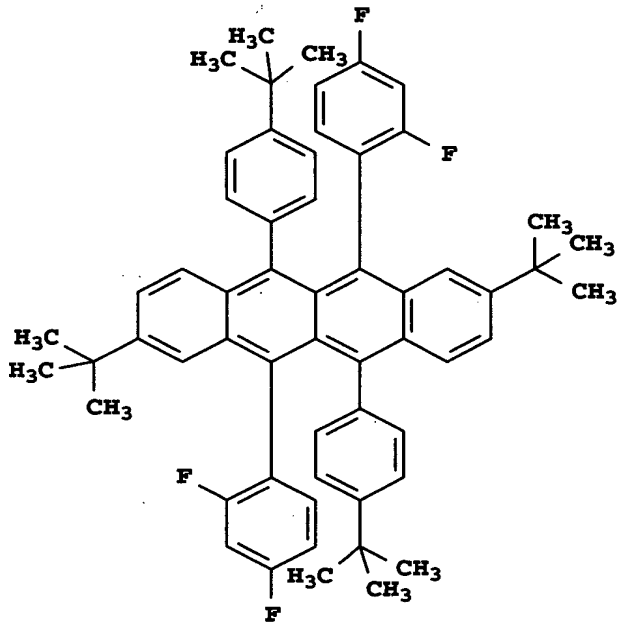

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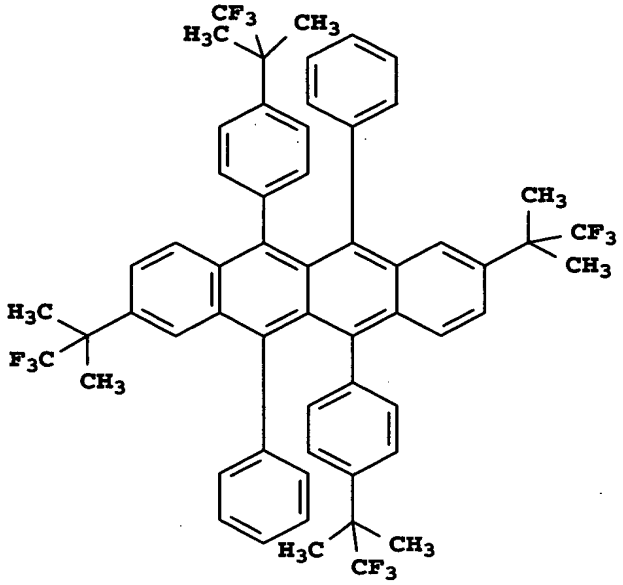

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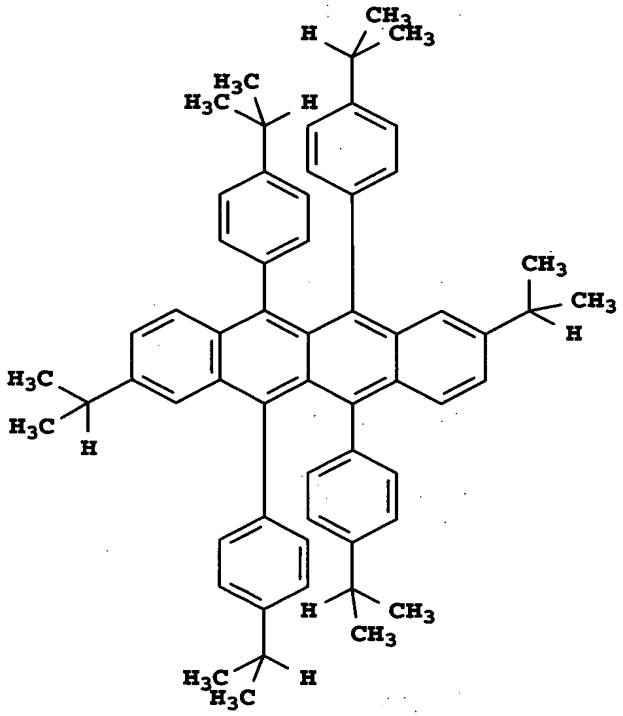

and

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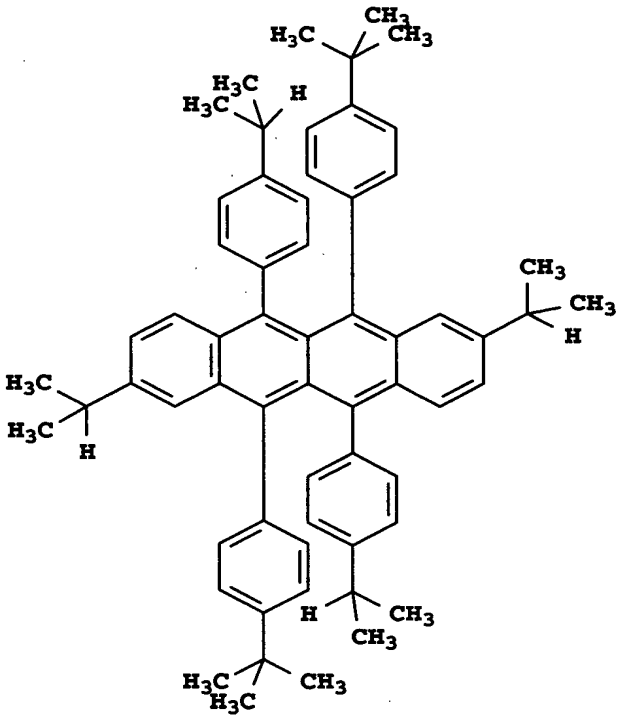

15. The device of claim 14 wherein the hole-transporting layer comprises a host material and a yellow-light emitting naphthacene compound, wherein the concentration of said naphthacene compound is in a range of greater than 0 and less than 50% by volume of the host material.

16. The device of claim 15 wherein the concentration of said naphthacene compound is in a range of greater than 0 and less than 30% by volume of the host material.

17. The device of claim 15 wherein the concentration of said naphthacene compound is in a range of greater than 0 and less than 15% by volume of the host material.

18. The device of claim 1 wherein the blue light emitting material includes the distyrylamine compound as shown by the formula below, or its derivatives.

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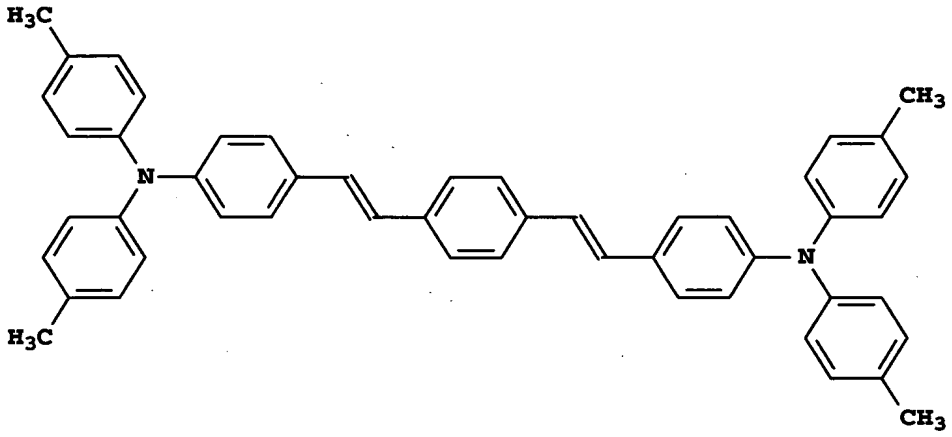


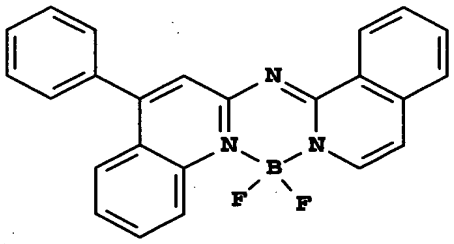
19. The device of claim 1 wherein the blue light emitting material further includes a perylene compound or its derivatives.

20. The device of claim 19 wherein the perylene derivative is 2,5,8,11-tetra-tert-butyl perylene (TBP).

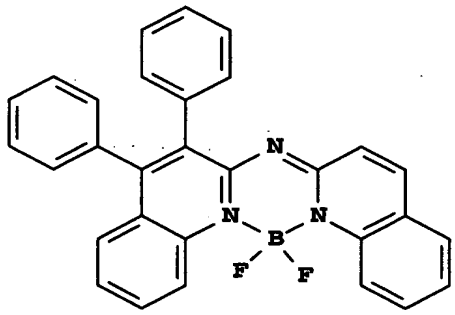
21. The device of claim 1 wherein the blue light emitting material further includes a bis(azinyl)amine boron complex.

22. The device of claim 21 wherein the blue light emitting material comprises at least one compound represented by the following formulae.

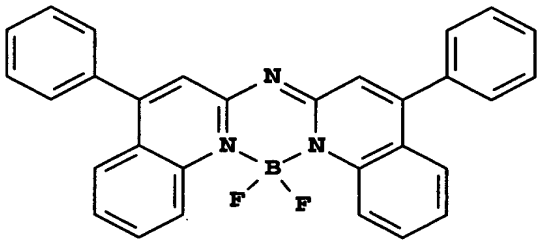
B-1



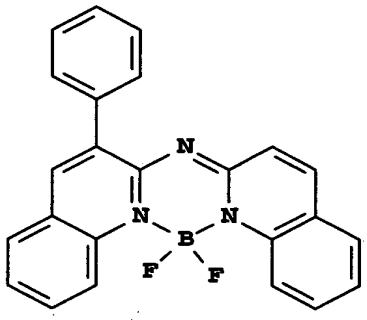
B-2



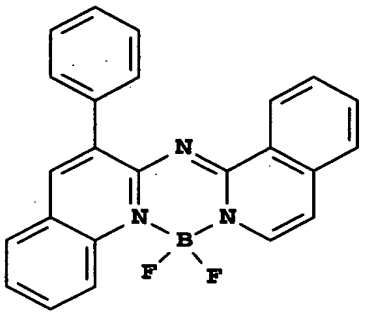
B-3



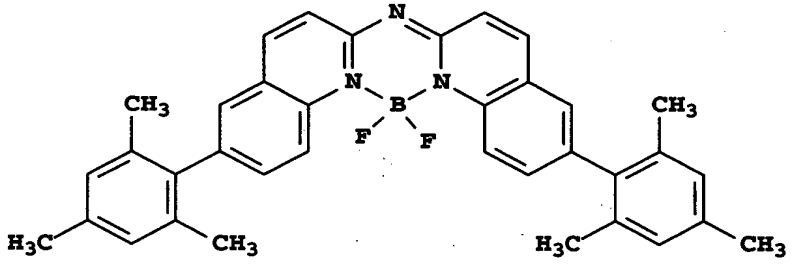
B-4



B-5

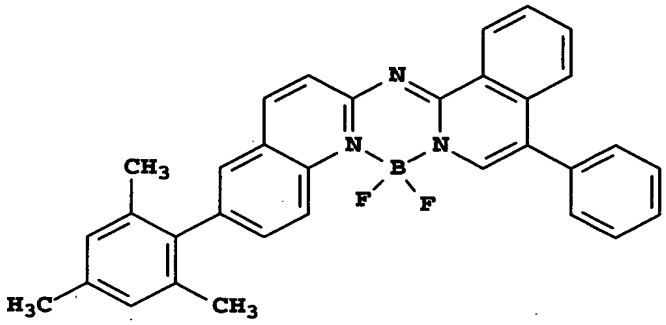


B-6



and

B-7



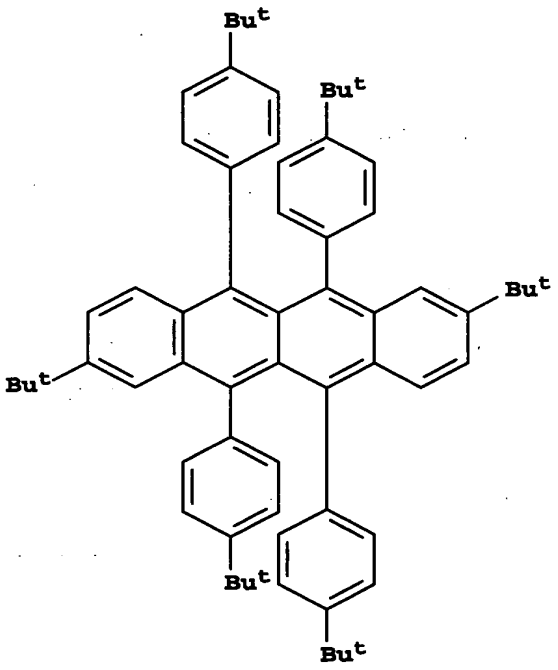
23. The device of claim 1 wherein the blue-light emitting layer comprises a host material and a blue-light emitting material, wherein the concentration of said blue-light emitting material is in a range of greater than 0 and less than 20% by volume of the host material.

24. The device of claim 1 wherein thickness of the hole-transporting layer is from 10nm - 300nm.

25. The device of claim 1 wherein the hole-transporting layer includes two or more sub layers, the sub layer closest to the blue light-emitting layer being doped with yellow light emitting materials.

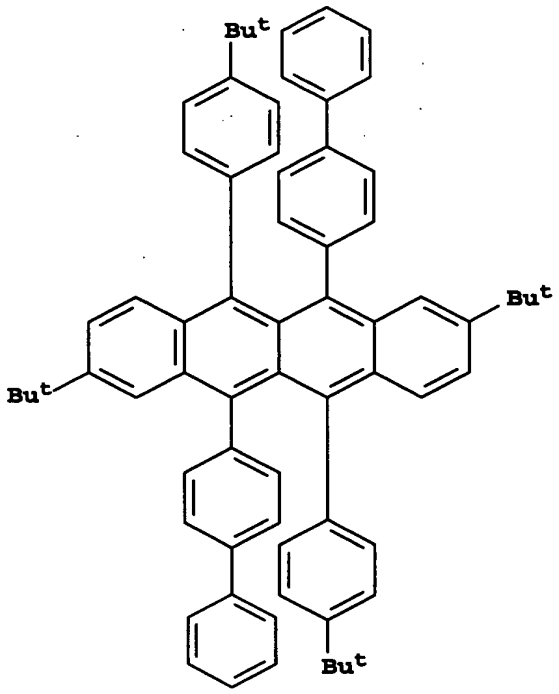
26. The device of claim 25 wherein the emitting material in the hole transport layer is selected from the following:

Inv-1



and

Inv-2



and the thickness of the layer containing the yellow-light emitting material is in a range from 1nm - 300nm.

27. The device of claim 1 wherein the thickness of the blue light-emitting layer is in a range from 10nm - 100nm.

28. The device of claim 1 wherein a hole-injecting layer is provided between the anode and the hole-transporting layer.

29. The device of claim 28 wherein the hole-injecting layer comprises CFx, CuPC, or m-MTDATA.

30. The device of claim 28 wherein the thickness of the hole-injecting layer is 0.1nm – 100nm.

31. The device of claim 1 wherein thickness of the electron-transporting layer is in a range from 10nm - 150nm.

32. The device of claim 1 wherein the cathode is selected from the group consisting of LiF/Al, Mg:Ag alloy, Al-Li alloy, and Mg-Al alloy.

33. The device of claim 1 wherein the cathode is transparent.

34. The device of claim 1 wherein the electron-transporting layer is transparent.

35. The organic light-emitting diode (OLED) device of claim 1 wherein the electron-transporting layer is doped with a green light-emitting material or a combination of green and yellow light-emitting materials.

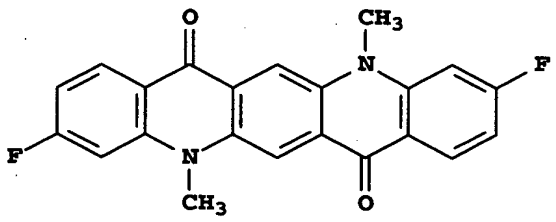
36. The device of claim 35 wherein the green light emitting material in the electron-transporting layer includes a coumarin compound.

37. The device of claim 36 wherein the coumarin compound includes C545T or C545TB.

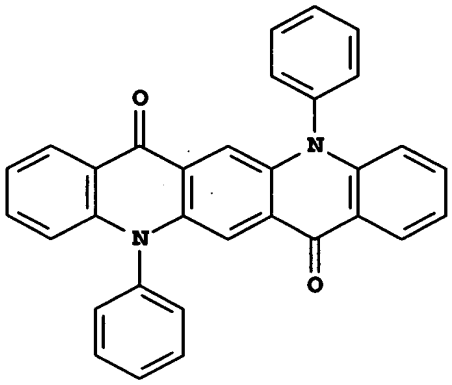
38. The device of claim 35 wherein the green light emitting material is selected from a quinacridone and a bis(azinyl)methene boron complex group.

39. The device of claim 35 wherein the green light-emitting material is selected from the following formulae:

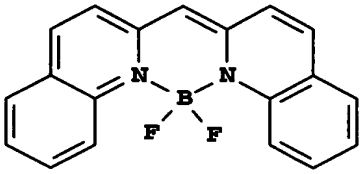
G-1



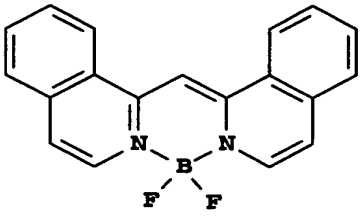
G-2



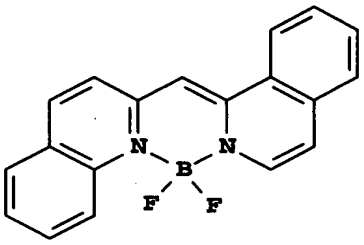
G-3



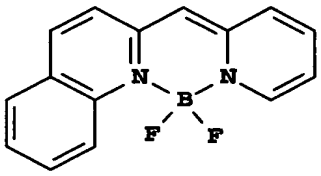
G-4



G-5

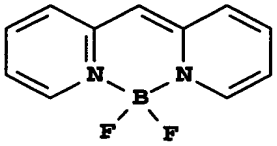


G-6



and

G-7



40. The device of claim 35 wherein the green light emitting material concentration is in a range from 0.1 - 5% by volume of the host material.

41. The device of claim 1 further including buffer layer disposed on the cathode layer.

42. The device of claim 40 wherein thickness of the buffer layer is in a range from 1nm - 1000nm.

43. The device of claim 1 further including a color filter array disposed on the substrate or over the cathode.

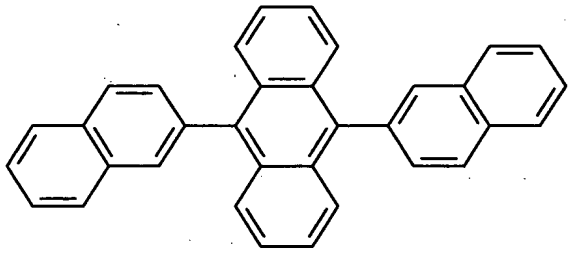
44. The device of claim 40 further including a color filter array disposed on the buffer layer.

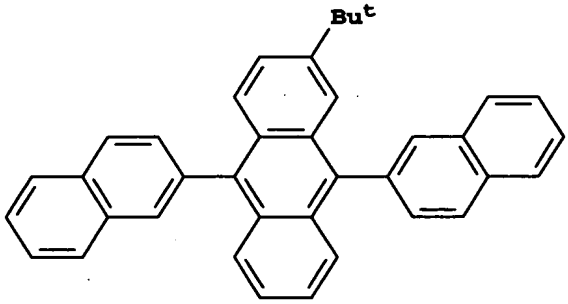
45. The device of claim 1 further including thin film transistors (TFTs) on the substrate, to address the individual pixels.

46. The device of claim 1 wherein the hole-transporting layer includes an aromatic tertiary amine.

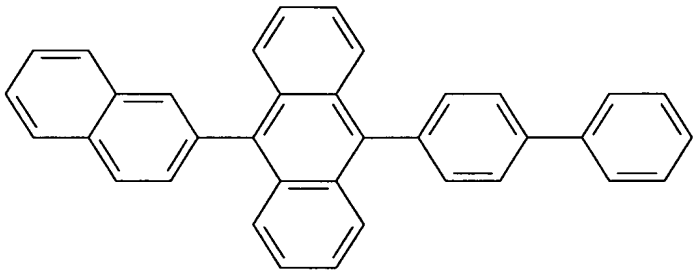
47. The device of claim 1 wherein the electron-transporting layer includes copper phthalocyanine compound.

48. The device of claim 1 wherein the blue light-emitting layer includes host material comprising an anthracene compound as shown by the formulae below, or their derivatives:

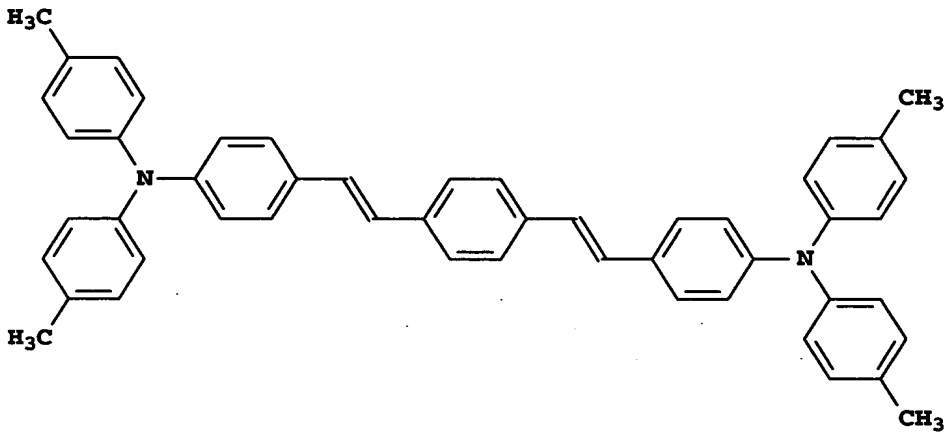




and



and a blue light-emitting material that includes the distyrylamine compound as shown by the formula below, or its derivatives:



49. The device of claim 1 wherein the hole-transporting layer and the blue-light emitting layers are co-doped with other dopants.

50. The device of claim 49 wherein the co-dopant in the hole-transporting layer is t-BuDPN and the co-dopant in the blue-light emitting layer is NPB.

51. The device of claim 1 comprising a triplet emitter compound.

52. The device of claim 1 comprising a polymeric light emitter.